소프트웨어학과 2019312995 최정훈

1. Code

First, tri_dup_mode is a Boolean that is used to control which retransmission mode to use. By setting it to True, fast retransmission with 3 duplicate acks is chosen. Setting it to false will make the program rely only on timeouts.

lost_pkt_td is a list to store retransmitted packet numbers when in fast retransmit mode. lost_pkt_to is a list to store retransmitted packet numbers when in timeout only mode. The length of list is printed at the end of program to show results. latency_sum is a global variable used to keep track of latency throughout the program. This is variable is used with no_pkt at the end of program to compute latency and throughput.

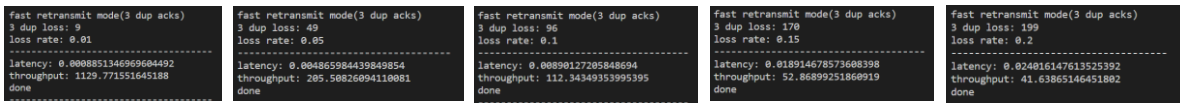
The prev_ack variable inside the thread target function is used to check whether the received ack is a duplicate ack. If it is, global variable dup_count is incremented which is a variable to keep track of number of duplicate acks. When dup_count exceeds 3, the program will print '3 dup acks detected', appends packet number to list and retransmits using tdupack_flag. latency_sum is updated on every reception.

In the main function, a condition is added for retransmitting when 3 duplicate acks are detected. This branch will only execute when tri_dup_mode is True.

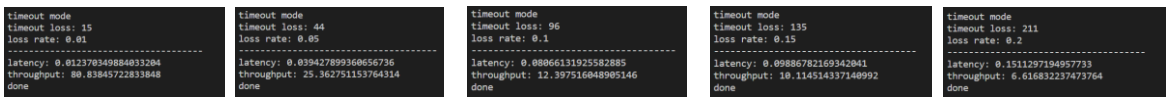
On either timeout or 3 duplicate acks, ssthresh and win variables are updated. On 3 duplicate acks, win is set to half of win (win//2) and ssthresh is set to half of win as well. On timeout, win is set to 1 and ssthresh is updated to half of win. A guard condition is set to prevent ssthresh into being set to 0.

2. 3 Duplicate Acks vs Timeout

Below is a comparison of 3 duplicate acks and timeout with 1000 total packets, and loss rates of 1%, 5%, 10%, 15% and 20%.



Comparison of 3 duplicate ack latency & throughput



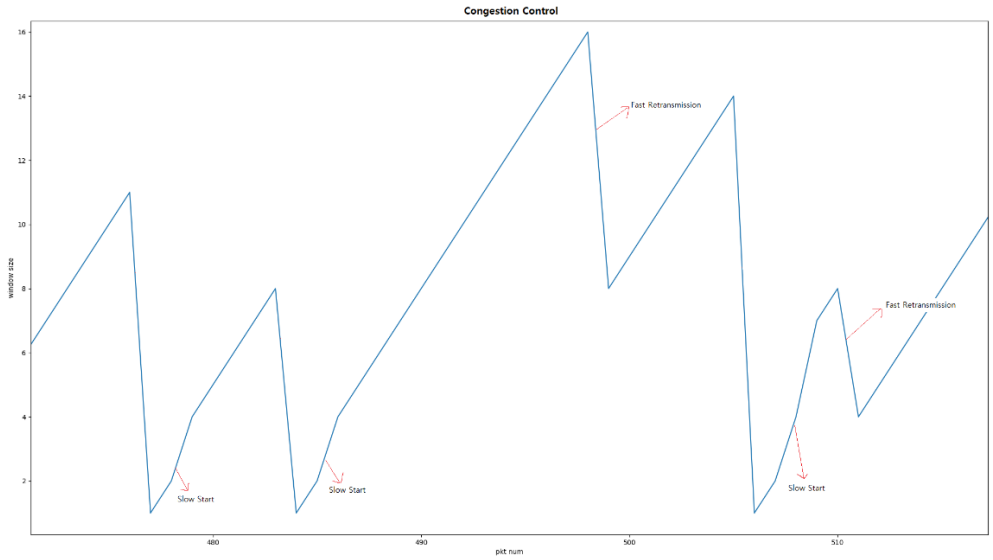
Comparison of timeout latency & throughput

It can clearly be seen that fast retransmission has much higher throughput than using timeout only. Since it is clear that a packet is lost when multiple duplicate acks are being received, it is reasonable to retransmit when 3 duplicate acks are detected. Throughput

decreases dramatically from loss rate 1% to 5%. We can also observe that throughput and loss rate is inversely proportional.

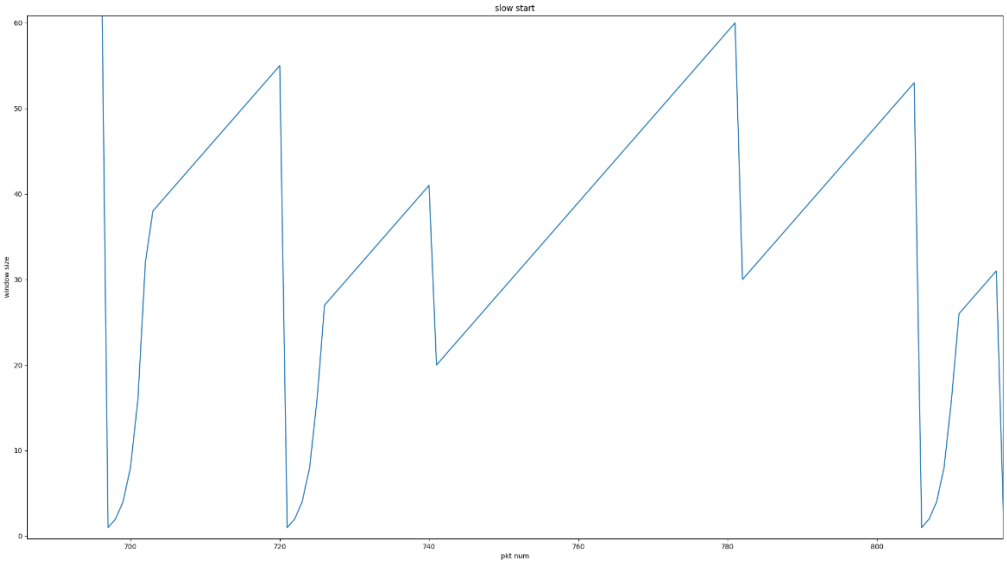
3. Slow Start

Below is a sample execution of slow start, plotted with matplotlib. Number of packets was 1000, loss rate was 10%, server queue size was 20 and queueing delay was 0.2.



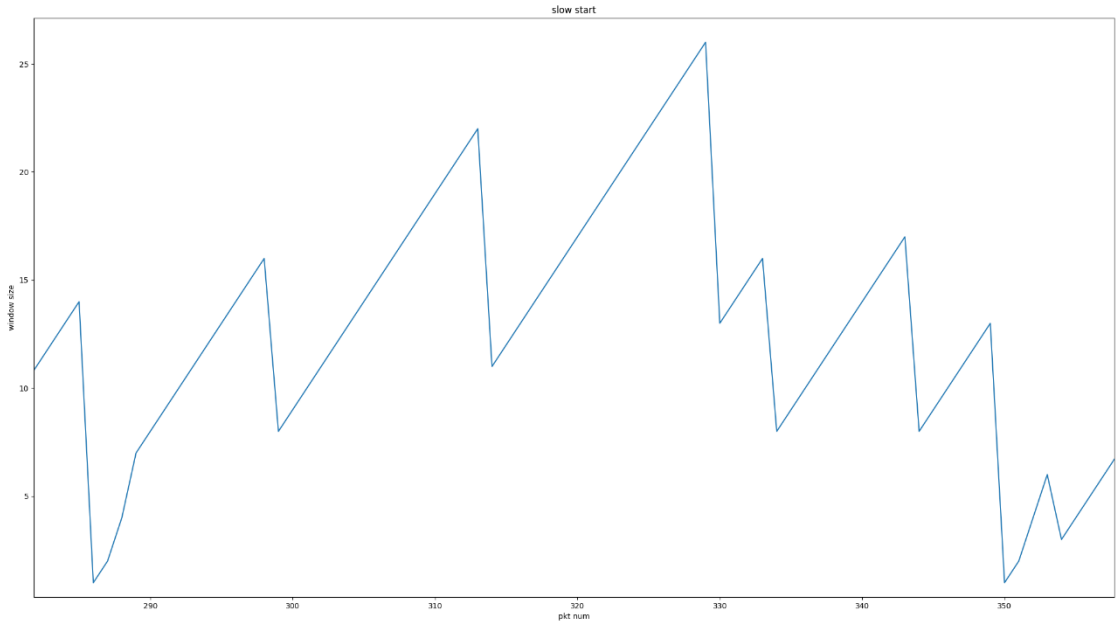

```
loss rate: 0.1
-----------------------------------
latency: 0.04077153706550598
throughput: 24.526914410740524
```

Below is another sample execution with same number of packets, server queue size and queueing delay, and loss rate was set to 5%.




```
loss rate: 0.05
-----------------------------------
latency: 0.032848089456558226
throughput: 30.44317086759354
```

Sample executions with queueing delay of 0.4 was also tested, but execution time was noticeably high and was clear that performance is worse compared to the sample executions above.




```
loss rate: 0.05
-----------------------------------
latency: 0.14466022396087647
throughput: 6.912750254489107
```